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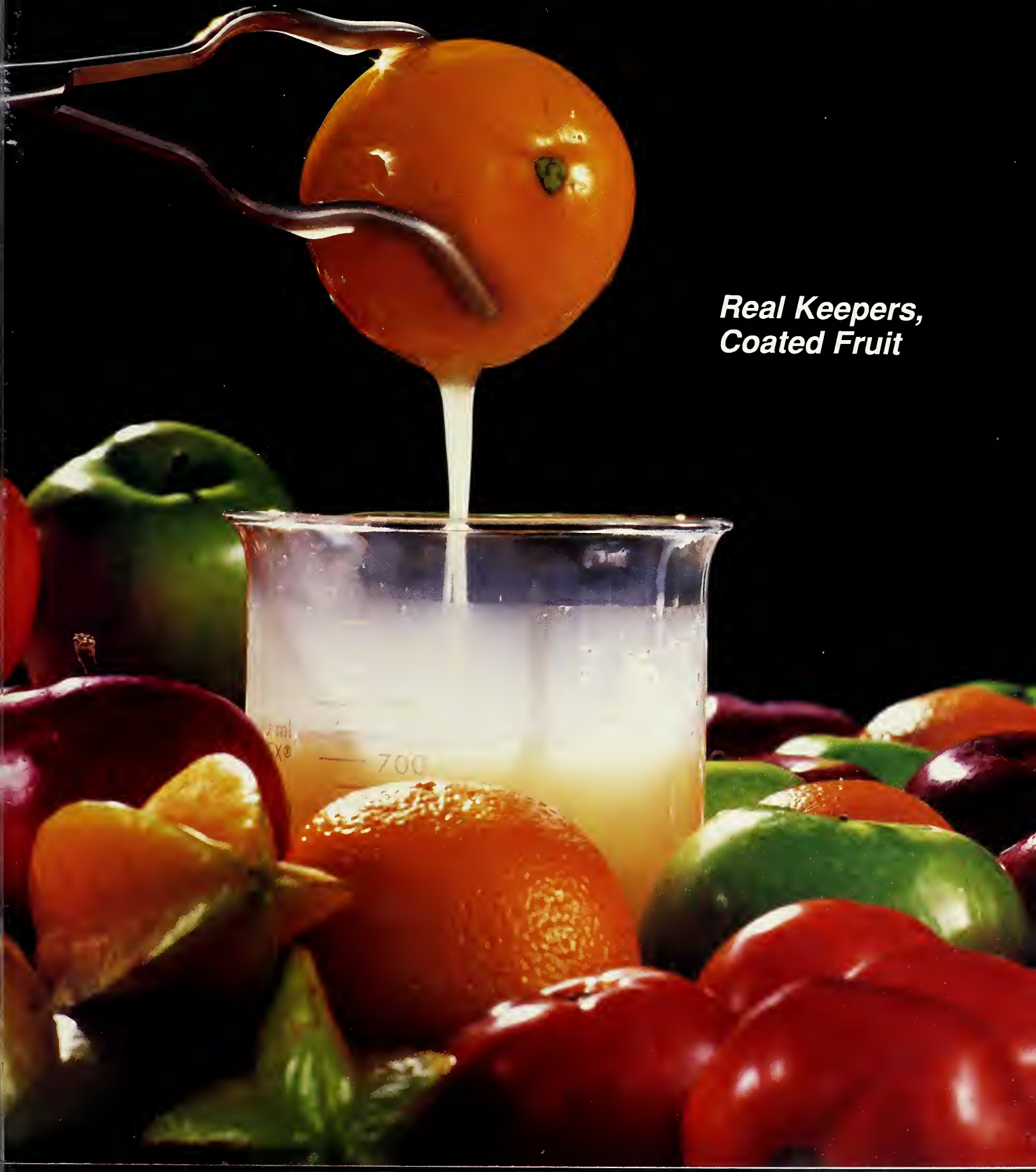
Agricultural Research



Real Keepers, Coated Fruit

Animal Protection Research: From Conception to Consumption

Foods derived from animals supply 70 percent of the protein, 35 percent of the energy, 80 percent of the calcium, and 60 percent of the phosphorus in an average American's diet. They are major sources of vitamin A, the B vitamins, and essential trace elements and are generally considered essential to a healthy, balanced diet.

Furthermore, animal production generates about half of all farm income in the United States, and exports of animal products make up a significant share of total U.S. trade in farm commodities. By any yardstick, therefore, animal science is important to our personal well-being and to the health of our national economy.

How can we ensure the viability of animal agriculture in the United States? One key is research to protect animals from losses caused by diseases, insects, parasites, and stresses. Besides being one of the fastest-growing segments of the Agricultural Research Service program, animal protection is also—from my point of view—one of the most exciting.

ARS' animal researchers are studying how livestock are raised and handled from conception to consumption. We're developing whole-herd protective management systems that emphasize prevention of disease, rather than treatment of individual animals and their symptoms. We're breeding genetic resistance to disease into animals. We're anticipating problems before they occur, both from the viewpoint of an individual farmer and from the perspective of national and international agriculture.

The article beginning on page 17 of this issue of *Agricultural Research* illustrates the global perspective that we seek for our animal protection research. It describes the efforts of ARS scientists and their collaborators to develop safe, effective vaccines for babesiosis, or tick fever. Although babesiosis is not currently a problem in the United States, existing conditions in some parts of the country could allow this crippling disease to re-enter.

Besides keeping us vigilant to ensure that foreign diseases such as babesiosis don't gain—or regain—a foothold in the United States, this international perspective helps us stay aware of the special needs of foreign markets. Thus armed, we can help keep American animal products unadulterated by drug residues and other contaminants and competitive in the global marketplace.

Another story in this issue, on page 12, describes our progress toward understanding the dynamics of shipping fever, sickness in livestock that results from the stresses of transportation and confinement. These and other research results will lead to more humane, more productive, and more efficient ways to manage animals.

ARS is also in the midst of a vigorous program of modernizing its older animal research facilities and building new ones that will help us continue developing better ways to protect animals. Some of our key construction projects:

- **Plum Island Animal Disease Center, Greenport, New York.** We are working with USDA's Animal and Plant Health Inspection Service to upgrade and modernize our laboratory and quarantine facilities. This project will help Plum Island regain its position as the premier foreign animal disease facility in the world.
- **Southeast Poultry Research Laboratory, Athens, Georgia.** A proposed $2.5-million renovation in the fiscal year 1991 budget would further our research into *Salmonella*, exotic Newcastle disease, and avian influenza.
- **National Animal Disease Center, Ames, Iowa.** Facilities at this Center continue to be upgraded even more in anticipation of future animal research needs, especially in the biotechnology area. Biosafety improvement is a primary effort here.
- **Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, Nebraska.** We are looking forward to the late-April dedication of a new, multi-million-dollar Animal Health Systems Research Laboratory, one of the finest of its kind in the world. Emphasis will be on whole-herd health maintenance programs for beef cattle, swine, and sheep.
- **Regional Poultry Research Laboratory, East Lansing, Michigan.** We are looking into the feasibility of renovating this internationally renowned facility for research on viral diseases of poultry.
- **Arthropod-Borne Animal Diseases Research Station, Laramie, Wyoming.** We have upgraded this key laboratory for research on bluetongue and similar diseases of beef cattle and sheep.

Improved facilities, better equipment, new laboratory techniques, eager scientists, invigorated leadership: These factors are giving the agency a new sense of purpose and a renewed commitment to progress in animal protection through cooperation with the states, other agencies, and industry.

Robert R. Oltjen
Associate Deputy Administrator
Agricultural Research Service

Agricultural Research

Cover: A new coating compound promises to extend the shelf life of fruit and vegetables.
Photo by Keith Weller. (K-3517-5)

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KEITH WELLER

Chemist Myrna Nisperos-Carriedo checks differences in browning between a coated carambola (green) and an uncoated one. (K-3515-12)

Keep it Under an Edible Coat

Mounds of fresh, firm, colorful, nutritious fruits and vegetables in the local supermarket—nothing is more appealing to a health-conscious food shopper.

Usually, the produce in these eye-catching displays has been picked days earlier and shipped hundreds of miles or more. To prevent spoilage and retain the fresh-picked quality that consumers demand, most produce is shipped at reduced temperatures. But these lower temperatures can cause abnormal ripening, decreasing quality.

Some of the produce has been treated with a protective film—a wax coating that prolongs shelf life. The problem with such films is that they retard the ripening process for only a short time. Produce must still be shipped at reduced temperatures.

Chemist Myrna Nisperos-Carriedo is working on an inexpensive coating made with an edible vegetable oil that promises to further extend shelf life without harming produce quality. Her product allows storage at 70°F, normal room temperature.

"The base for our coating is commercially available oils or waxes and cellulose. But we add an emulsifier that the commercial blends don't have," she says. "So far, we've used our films on tomatoes, oranges, and carambolas."

"In experimenting with oranges, we made an interesting discovery. The film actually increased their important flavor volatiles."

KEITH WELLER

Biological laboratory technician Holly Hutchens applies liquid coating to pineapple oranges. (K-3510-10)

Nisperos-Carriedo, an ARS researcher in Winter Haven, Florida, says that edible films provide a barrier to moisture loss or air exchange. This allows the films to retard ripening in much the same way as controlled atmosphere storage, which is effective but very costly.

Fragrant compounds formed by the chemical combination of an acid and an alcohol, are what give orange juice its "fruity" taste.

Keeping produce healthy and fresh depends on the permeability of the film to oxygen, carbon dioxide, and ethylene. The film inhibits the uptake of oxygen, essential to producing ethylene, a natural growth regulator that controls ripening in fruit.

Nisperos-Carriedo experimented with three groups of mature green tomatoes: one treated with the emulsified film, one with the commercial blend minus the emulsifier, and a control group.

After 14 days of storage, only 40 percent of the tomatoes treated with the emulsified film began ripening. This compared to ripening of about 80 percent of the fruit receiving the commercial-blend-minus-emulsifier, and 100 percent of the untreated tomatoes.

"Fruit treated with the commercial blend without the emulsifier developed stem-end rot and ripened unevenly, making the tomatoes look blotchy," Nisperos-Carriedo says.

By adding emulsifier she obtained better color development and eliminated fungal growth.

"I think we can get even better results with this film. Since we handpainted it on the tomatoes, we probably missed some sections of the surface. Maybe spraying the mixture on would more completely cover the fruit," she says.

Applying protective coatings to prolong freshness in citrus is not new. Waxes and other types of coatings, including sucrose esters of fatty acids, have been used since 1930 to keep oranges from drying out and to give them an attractive gloss.

These coatings preserve the appearance of the citrus, but their effect on flavor is not fully known.

Nisperos-Carriedo tested her newly developed coating on mature pineapple oranges.

She found that after 8 to 10 days in storage at 70°F, juice extracted from the oranges contained up to 14 times the usual flavor volatiles. Volatile esters, fragrant compounds formed by the chemical combination of an acid and an alcohol, are what give orange juice its "fruity" taste.

The Fragile Carambola

With a shelf life of about 3 days, the tropical fruit carambola is so perishable it can barely be shipped. Nisperos-Carriedo has also applied the emulsified formulation to this exotic, Florida-grown fruit. By the third day in storage, edges of the uncoated, star-shaped fruit turn an unsightly brown. But fruit coated with Nisperos-Carriedo's formulation showed less browning and fungal growth, even after 8 days of storage. She plans further tests with other types of antioxidants to extend the storage life of carambolas.

Nisperos-Carriedo plans to apply for a patent for her formulation.

Alley E. Watada, head of the ARS Horticultural Crops Quality Laboratory in Beltsville, Maryland, says that fresh fruit and vegetables suffer anywhere from 12 to 20 percent spoilage loss from farm gate to retail outlets.

"In fact, for crops such as strawberries and raspberries, losses can be as high as 40 percent," he says.

Watada expects the fresh fruit and vegetable industry to have a vital interest in results from the coatings research.—By **Doris Sanchez,** ARS.

Myrna O. Nisperos-Carriedo is at the USDA-ARS Citrus and Subtropical Products Research Laboratory, Winter Haven, FL 33880 (813) 293-4133. ◆

KEITH WELLER

Coated oranges retain more of the important flavor components, according to chemist Myrna Nisperos-Carriedo. (K-3512-3)

Nutrition Probes For the 90's

Scientists seek better ways to score your vitamin and mineral health.

PERRY RECH

Nutritionists dream of the day when you'll be able to walk into your doctor's office and, after a brief battery of inexpensive and relatively painless tests, find out if you're getting all the vitamins and minerals you need.

Such probes could also aid U.S. health officials who every 5 years or so pick some 30,000 Americans at random for the nation's nutrition census, says James M. Iacono, director of ARS' Western Human Nutrition Research Center at San Francisco. The survey profiles what Americans eat.

This country's nutrition standards—the Recommended Dietary Allowances, or RDA's that end up on vitamin pill bottles or labels of packaged foods—rely heavily on survey results.

"We'd like to offer tests that make it economical and practical to measure nutrients that aren't typically included in the survey, like vitamin B6 or selenium," says Iacono. "For other nutrients such as vitamin A, we think we can improve the most commonly used tests."

Center scientists are gearing the tests to detect slight or marginal deficiencies of vitamins and minerals—the type of shortage most common in this country. Unlike severe deficiencies, marginal shortages lack easy-to-diagnose symptoms.

Scientists already know that slight deficiencies of some nutrients can be cause for concern. Research chemist Betty J. Burri, co-developer of a new vitamin A test, says shortages of that nutrient have been linked to lowered immune response and increased incidence of cancer.

Millions of Americans, says Burri, don't get enough vitamin A (retinol). Most notable in this group are low-income people who don't regularly eat liver, fresh milk, or the fresh dark green or brightly colored vegetables (carrots, squash, tomatoes, and corn) that are in rich vitamin A's precursor, betacarotene.

Because most healthy people store 90 to 95 percent of their vitamin A supply in their liver, one of the best ways—though not often used—to measure the nutrient is to examine a tiny chunk of the liver. Burri and colleague Mark A. Kutnink propose an alternative that's simple, quick, inexpensive, and relatively painless. They opt for running a small sample of blood through a high-performance liquid chromatograph to separately measure two different forms of a retinol-binding protein—something earlier tests can't do.

Burri will compare this test to a half dozen other well-known procedures, like the dark adaptation exercise (if you're short of vitamin A, your eyes take longer to adjust to the dark) in a study that starts this year.

Measuring Niacin

The key to measuring your niacin status might be the ratio of two niacin-containing chemicals, NAD and NADP, in your blood, says research chemist Robert A. Jacob at the center. "Any niacin you eat, like in meat or dairy products, is ultimately converted into NAD or NADP," he says. "Those chemicals are used in basic cellular reactions,

◀ **Research nutrition scientist Monica Schaeffer (right) prepares ARS physiologist Theresa Barbieri for a startle test that measures the central nervous system's reactivity. (K-3525-1)**

▶ **Chemist Robert Jacob examines blood serum test results from an automated analyzer that is used to determine nutrient levels in blood. (K-3527-11)**

PERRY RECH

such as burning fuel for energy." Without that energy, you're dead.

Jacob and co-researchers at UCLA's School of Public Health hit on the idea of analyzing the ratio of the two chemicals during an experiment with volunteers. NAD levels decreased some 70 percent when niacin intake dropped, then went back up when intake increased. Levels of the other chemical never wavered.

"Our results indicate that if you have an NAD to NADP ratio of less than 1, you're probably niacin deficient," says Jacob. There's no ideal ratio yet, so everyone's initial ratio is a personalized checkpoint that could be monitored from then on and serve as sort of an early warning alert to changes in niacin levels. With more work, the test may someday help U.S. researchers studying effects of marginal niacin shortages.

Do We Get Enough B-6?

Other center scientists have refined a test for measuring vitamin B6. Their test employs a standard piece of lab equipment—the automated chemistry analyzer—and a small sample of blood.

The procedure measures changes that occur when B6 is added to two enzymes in red blood cells. Both enzymes must have B6, and both are already the basis of some other, long-standing B6 tests, according to research chemist James H. Skala, now retired. "But the other B6 tests are either done by hand, or—if automated—only measure one of these two key B6 dependent enzymes," he says.

Skala produced the analytical system with medical technologist M. Denise Gretz at the center, and U.S. Army research chemist Paul R. Waring at Letterman Army Institute of Research, San Francisco. Because a hospital lab could process as many as 100 samples a day using the automated procedure, the test might prove suitable for large-scale nutrition surveys, Skala says.

Half the people in the United States today may be getting less than 70 percent of the RDA for B6. Good sources of the nutrient are whole-grain cereals, bananas, potatoes, beans, seeds, poultry, lean red meats, and salmon and most other fish.

Skala and Gretz later added two other enzyme-based assays, one for B1 (thiamin) and one for B2 (riboflavin) to their automated system. Preliminary results indicate the comprehensive test is highly accurate. It's also easy to run, fast, and demands only about $1 worth of chemicals for each sample.

While your blood may be the sample of choice for some researchers, others, like research nutrition scientist Monica C. Schaeffer, suggest a "functional" test of some activity linked to vitamins might provide early clues to shortages.

In studies with rats and humans, she looks for things that go awry when B6 levels drop, like a sluggish response to the sensation of a puff of air hitting your face, or a longer-than-normal delay in moving your finger from an uncomfortably warm surface. "Nerves are involved in these responses, and they don't work properly if you're short of B6," she says.

PERRY RECH

Chemist Chris Hawkes reviews a test result on selenium that will help him define the range between human nutritional requirements and levels that are toxic. (K-3530-7)

In a study planned for next year, Schaeffer will feed volunteers varying levels of B6, then test these responses and others, like eye-and-hand coordination, recognition time, and short-term memory of volunteers who play a computer game specially designed to challenge these skills. She's borrowing the game from ARS research psychologist James G. Penland at the Grand Forks, North Dakota, Human Nutrition Research Center, who uses it to pinpoint changes that might be caused by mineral deficiencies.

Checking for Vitamin C

Meanwhile, a few cells gently removed from inside your cheek, by carefully scraping it with a soft toothbrush, may reveal if you're getting all the vitamin C you need. "This isn't a new idea," says research chemist Robert Jacob, "but our experiment may be the first to indicate that buccal cells can accurately reflect your vitamin C intake." He tried it out with volunteers who lived at the center for a study of this and other vitamin C probes.

Vital Traces

At the opposite end of the nutrition spectrum are nutrients we only need in tiny amounts—trace minerals. The recommended range for molybdenum is only 75 to 250 micrograms a day for adults, an amount that's "hardly visible," says research nutrition scientist Judith R. Turnlund. Most Americans get this mineral in milk, beans, breads, and cereals.

PERRY RECH

In a test to determine effects of vitamin levels on eyesight, a volunteer is asked to quickly sort poker chips in dim light. (K-3528-6)

PERRY RECH

From one sample of red blood hemolysate, medical technologist Denise Gretz can measure four enzymes to reflect the status of vitamins B1, B2, and B6. (K-3529-7)

Unfortunately, the recommended intake "is based in part on scanty, obsolete data," she says. "Part of the problem is that nobody really knows how to find out whether a person is short of molybdenum."

One approach she tried in a study with healthy young men was to feed them doses of compounds that would, if volunteers had enough molybdenum, break down into byproducts the researchers could detect and measure.

"The enzymes that convert the incoming compounds into byproducts can't function without molybdenum. We expect that if you have enough molybdenum to keep these enzymes on the job, we'd see an increase in excretion of byproducts.

"Until our experiment, no one had tried this 'loading dose' approach to measuring molybdenum. It's used to test other nutrients, so we're hoping it will work for molybdenum."

Enzymes such as xanthine oxidase require molybdenum to perform complex chemical chores like converting food into energy or preventing toxic accumulations of sulfites.

Selenium, Essential—and Toxic

Another trace mineral, selenium, was assigned an RDA for the first time last year—70 micrograms for men and 55 micrograms for women. Both amounts are "less than a grain of salt," says W. Chris Hawkes, a research chemist.

Although we need selenium for a healthy heart, too much of the mineral can be toxic. Hawkes sees selenium tests as important tools in research that might someday precisely define selenium's danger zone.

Right now, he's working on two tests. One monitors a reaction that occurs when selenium from a blood sample reacts with the chemical tetrazolium to produce a blue color. His experiments indicate the test is just as sensitive as an alternative method, which uses a less common piece of equipment and appears more difficult to automate. His test is more than 90 percent accurate, but it may take another year or so to find out if it can be upped to 100 percent.

The second test is a "completely new approach" to analyzing a selenium-dependent enzyme, glutathione peroxidase. Hawkes produced what he thinks is the first fully automated method that uses this enzyme to measure selenium intake.

He had a strong incentive. To do his part in a California public health study of selenium, Hawkes had a staggering load of 5,000 blood samples to analyze.

"It was a very high-pressure situation," says Hawkes. "If it weren't for the automated test, we might not have been able to do the job."—By **Marcia Wood,** ARS.

James M. Iacono and colleagues are with USDA-ARS, Western Human Nutrition Research Center, P.O. Box 29997, Presidio of San Francisco, CA 94129 (415) 556-9697. ◆

Weeds Attract Root-Dwelling Bacteria

Bacteria, whipping their hair-like appendages, or flagella, purposefully swim through dark watery soil toward their favorite foods—organic substances that are exuded from a plant's root pores.

In studies aimed at biological control of weeds, ARS microbiologist Robert J. Kremer and colleagues at the University of Missouri, Columbia, have often viewed such scenes through an electron microscope. They hope to learn enough about microbial populations associated with roots to manipulate them in ways that will make agriculture more efficient.

Both good and bad root bacteria (rhizobacteria) exhibit chemotaxis, behavior in which living organisms move toward (or in other cases, away from) specific substances.

A good bacterium might be destined to nourish alfalfa with nitrogen it fixes from air in the legume's root nodules. For example, good rhizobacteria might kill fungi and other microorganisms that inflict diseases on crops.

But the bacteria that most interest Kremer are the ones that make weeds sick, causing them to produce fewer seedlings. His research may strike a sympathetic chord with U.S. farmers who, despite advances in chemical weed control since the 1940's, suffer annual crop yield losses of about 12 percent from weeds.

Each year in the north central and southern states, corn and soybean farmers lose an estimated $300 million to just one weed—velvetleaf. A single plant typically produces some 8,000 seeds. Many of these lie dormant in the soil for years before sprouting. In 1986, Kremer found some rhizobacteria strains that overcame velvetleaf seeds' tough outer coat, causing them to rot before they could germinate.

Kremer also found a strain that reduced top growth of 14-day-old velvetleaf seedlings by 88 percent in greenhouse tests. Microphotographs showed that crevices between the stunted seedling's root cells housed up to 250 million microbes per inch of root.

"Finding out how the bacteria become attached to weed seedlings may help us someday select and develop strains for biological control," Kremer says.

Mississippi State University microbiologist Maria F. Tejada-Begonia worked with Kremer on rhizobacteria under an ARS research support agreement. Tejada-Begonia recently completed her Ph.D. thesis on how rhizobacteria are attracted to velvetleaf and birdsfoot trefoil seeds.

She chose birdsfoot trefoil in part for its increasing popularity as a forage crop, widely adapted to climatic and soil conditions in regions where alfalfa may or may not be grown. She also saw an opportunity to add to the scientific knowledge on chemotaxis of birdsfoot trefoil, which has seed qualities similar to those of many weed species.

Rhizobacteria that Tejada-Begonia isolated from the plant roots included *Pseudomonas, Alcaligenes, Enterobacter, Erwinia, Xanthomonas*, and *Flavobacterium*. Strains of *Pseudomonas* and *Erwinia* currently show the most potential as biological herbicides.

Conducting biochemical analyses of seed exudates, Tejada-Begonia found those of velvetleaf and trefoil contain amino acids, sugars, organic acids, and phenolic compounds. Seedlings' roots produced even more of these chemicals. The scientists are now sorting out which of these chemicals attract rhizobacteria. Each species and strain of crop plant or weed may have its own composite profile of attractive substances, Kremer says.

The scientists are also looking at specific substances and identifying the bacteria strains that respond best to them. This information will help them explore the potential for applying strains as biological control agents that could be integrated into existing agricultural practices.

In preliminary field studies, the scientists picked two promising *Pseudomonas* strains. About 25

BOB NICHOLS

MSU microbiologist Maria F. Tejada-Begonia prepares to analyze velvetleaf seed extract with a high-pressure liquid chromatograph. (K-3459-10)

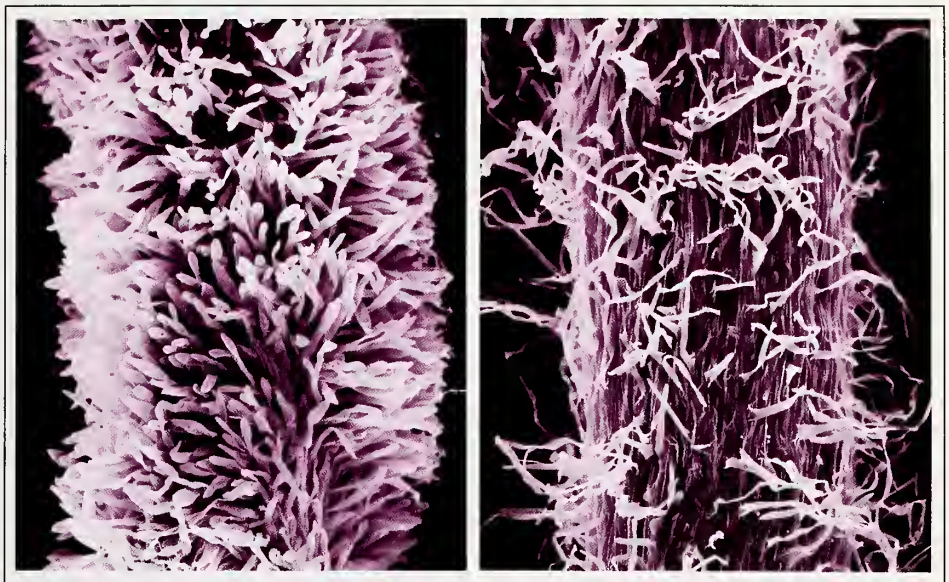
million bacteria were mixed with peat and applied to each of several 1-square-meter field plots where velvetleaf seeds were to be planted.

Two weeks after planting, these plots had 26 to 40 percent fewer weed seedlings than control plots where peat without rhizobacteria had been applied. And the rhizobacteria reduced average seedling heights by 35 to 43 percent.

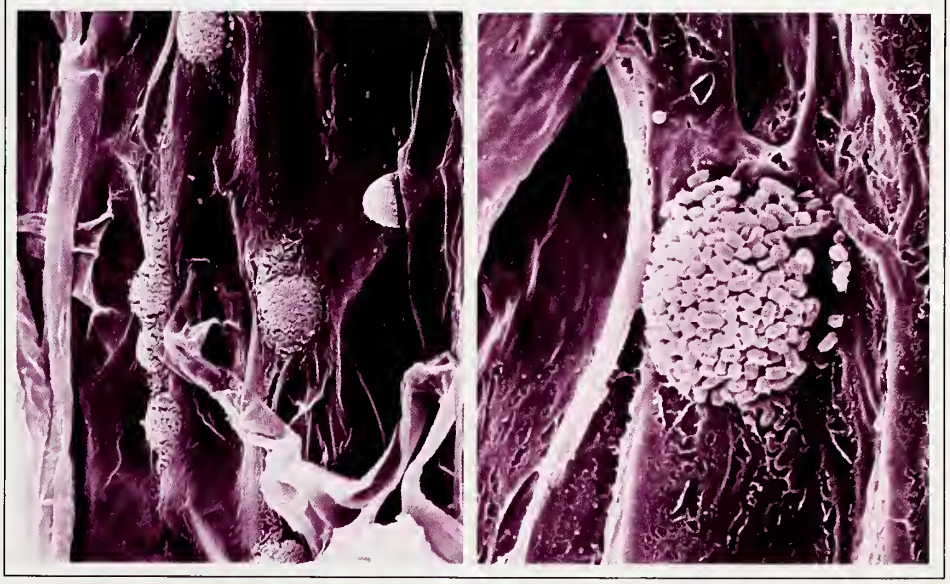
The applied rhizobacteria may not have performed as well had they not been protected from an adverse field environment by the peat carrier, Kremer says. To ensure that applying the microbes someday becomes a technologically feasible weed control, researchers will need to find the best ways to nurture the microbes and time their application.

Research may reveal ways to foster applied or naturally present rhizobacteria through such practices as rotating certain crops or growing a mix of forage species. An integrated pest management system that knocks out the weeds might also specify choices of fertilizers and other agricultural chemicals, Kremer says.—By **Ben Hardin,** ARS.

Robert J. Kremer is in USDA-ARS Cropping System and Water Quality Research, Room 138, Mumford Hall, University of Missouri, Columbia, MO 65211 (314) 882-6408. ◆



Above left, a healthy segment of taproot taken from velvetleaf boasts abundant, turgid roothairs that amply supply the plant with nutrients. In contrast, a similar specimen at right, inoculated with the soil bacterium Pseudomona, *shows roothairs that are scanty and collapsed, a condition that can cause the weed to grow poorly or die. Below, colonies of the weed-winnowing microorganism are magnified 1,300 times (left) and 4,000 times (right). Micrographs courtesy Maria Tejada-Begonia.*



Shipping Fever: Drive it Out!

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Out on the wide open Oklahoma prairie, scientists are using a new kind of cattle drive to probe the mysteries of livestock's natural biochemical intricacies.

Agricultural Research Service scientists, led by physiologist Michael T. Zavy, believe the interactions between cattle's brains and bodies hold the key to a costly ailment known as shipping fever.

To test this theory, they've conducted experiments that involved periodically shipping cattle from ARS' Forage and Livestock Research Laboratory at El Reno, Oklahoma, to Amarillo, Texas, and back.

Easily spread, shipping fever is actually bacterial pneumonia, the most common cause of contagious respiratory infections in calves and adult cows.

Among calves, up to 80 percent of the animals at a location may become infected. Symptoms include fever, coughing, nasal discharge, rapid breathing, and decreased appetite.

Lung damage from bacterial pneumonia can cause cattle to grow poorly, need more time and feed to reach market weight, or die—all resulting in higher production costs for cattle growers and ultimately higher beef prices for consumers.

The disease acquired its common name from its frequent development in cattle shipped long distances to feedlots, shows, and fairs, or assembled in sales barns and feedlots.

"This whole bovine respiratory disease complex is caused by a combination of bacterial, viral, and stress factors that set the animal up for bacterial pneumonia because its immune system is repressed," explains research associate Brian J. Hughes, an immunotoxicologist working with Zavy.

"The combination of stresses plus other factors results in a 10-percent average occurrence of bacterial pneumonia 6 to 14 days after the calves reach the feedlot."

The bacterium that most often causes the disease is normally present in the animal's nasal passages. As the calf is stressed, it proliferates and moves into the calf's lungs to cause infection.

> Up to 80 percent of the animals may become infected.

Ordinarily, the animal's immune system would fight off the bacterial invasion. But that defense system is somehow depressed, perhaps by the body's own chemicals, says Hughes.

"When the animal is stressed, the hypothalamus and pituitary in the animal's brain secrete chemicals," he says. "The chemical from the hypothalamus causes the pituitary to release adrenal corticotropin hormone, or ACTH. ACTH then acts on the animal's adrenal gland to produce glucocorticoids."

Glucocorticoids are as natural a part of a calf's life as the milk it gets from its mother. They play an important role in the energy balance of the animal, and are normally released in brief surges when the animal is stressed.

"But when an animal is stressed over a long time, such as by shipping, the glucocorticoid level remains elevated for a long time," says Hughes.

These glucocorticoids attach to receptors on cells all through the animal's body. Receptors are the body's light switches, a way in which it can turn cells off and on.

In the continually stressed animal, the switches are on all the time, and that can be bad news for the animal.

Cattle being loaded on a truck for shipment.

Hughes says: "It's not biologically smart to have the receptors occupied 100 percent of the time."

"We're trying to prevent the glucocorticoids from attaching and causing problems," he says. "We know that in studies where people have received doses of glucocorticoids, a whole realm of immune responses have been suppressed."

Hughes and fellow scientists hope to be able to use chemicals to block or mask the receptors before the glucocorticoids can attach to them. Producers might someday use such chemicals before shipping animals to counteract the ill effects of the trip.

These chemicals, known collectively as anti-glucocorticoids, include progestins—female sex hormones—and another synthetic hormone, melengestrol acetate or MGA.

"Progestins have been known for a while as anti-glucocorticoids," says Hughes. "What's new is the idea of using them in this sort of therapy."

Starting in the fall of 1988, ARS scientists took cattle from a free-range situation and confined them for 2 weeks to stress them.

During the animals' stay in the barn, six were given a daily dose of 50 milligrams of progesterone, a progestin; six received 1 milligram of MGA per day, and six received 10 milligrams of MGA daily.

At specific times during the study, the animals were given extra amounts of ACTH, the pituitary chemical that prompts the adrenal gland to release glucocorticoids. This allowed scientist to check the response of the animals' adrenal glands to the stimulus of ACTH.

At the end of the 2 weeks, the cattle were trucked to Amarillo and back—a 10-hour ride.

Two control groups of six animals each were also shipped: One had been confined but received no anti-glucocorticoids, while the second had been neither dosed nor confined.

The scientists had checked the glucocorticoid levels of the animals before the cattle were stressed by confinement. Those levels were checked again during confinement, before transit, and after transit.

"We have found that MGA is very good at damping the response of the adrenal gland—in other words, its release of glucocorticoids—when MGA is administered at a dose of 10 milligrams per head per day," Hughes says.

The researchers also looked at whether the anti-glucocorticoids actually helped the animals' immune systems respond normally, even when the animals were stressed and their glucocorticoid levels were likely to be higher.

To do this, the researchers gave the stressed animals a shot of *Brucella* strain 19, a vaccine for brucellosis, a bacterial contagious disease of livestock. Normally, the vaccine will cause the animal's natural immune system to go to work.

In fact, the cattle on 10 milligrams of MGA per day did not show a normal immune response to the vaccine when checked at 3, 7, 11, and 14 days after transport.

But the cattle that had received 50 milligrams of progesterone showed an immune response similar to that of the control animals that had not undergone the stress of confinement.

"This gives us hope that progesterone can offset some of the harmful effects of increased glucocorticoid production," Hughes says. "Now we need to look at using different levels or types of anti-glucocorticoids."—By **Sandy Miller Hays**, ARS.

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Looking for Love in All the Wrong Places

The tops of the space shuttle launch pads at Cape Canaveral's Kennedy Space Center are unlikely spots for courtship and frenzied lovemaking. But every fall and winter, thousands of paper wasps leave their nests and swarm up 300 feet to the tops of the launch towers to mate.

Paper wasps, so-called because they chew bark fibers into paper to make their nests, mistake the tall launch towers for their usual mating sites—trees and hilltops—says Agricultural Research Service entomologist Peter J. Landolt. Because Florida is relatively devoid of hills, a paper wasp doesn't have too many choices in mating spots, he says.

HAL REED

Paper wasp resting on a bolt high atop a tower.

"The launch towers and other manmade structures are frequently the tallest things in an area," he says, noting that the wasps will see the towers and swarm there from up to a mile away.

Every September for the last 5 years, the mating swarms have departed from nests in bushes or on houses. About 2 years ago, National Aeronautics and Space Administration officials sought help in the form of a reliable control method from Agricultural Research Service entomologists Landolt and Hal C. Reed, both of the Insect Attractants, Behavior, and Basic Biology Research Laboratory in Gainesville, Florida.

Thus far, the scientists have worked out a scenario that they believe describes the annual mating ritual. "We still need to do tests to confirm much of what we believe, but we're pretty sure we understand most of the behavior," Reed says.

Girl Meets Boy, Wasp Style

To begin the mating ritual, literally thousands of males begin leaving their nests in September to swarm at Kennedy, he says. The males aggregate around the launch pad's crane, which has a long arm, and near the crane motor's housing room. They fly around, staying in an area of about 20-30 feet in diameter.

There, they search for anything that protrudes—a bolt, for example—to sit on. After sitting down, they rub their heads and their tails on the perch to release sex attractants, or pheromones, into the air. In an increasing frenzy, the males begin to fight each other for a perch to sit on.

They bite. They wrestle. And they try to knock a perched buddy off of his bolt.

"We believe each male wants an ideal spot to sit and wait for virgin females to arrive so he can mate," says Landolt, who notes that the gland-rubbing behavior serves to release male pheromone into the air. "Every male wants *his* pheromone odor to be strongest so that females will be attracted to him."

Next, hundreds of females, responding to both the permeating aroma of pheromone chemicals and the desirable sight of the tall launch pad tower, leave their nests and swarm to the top.

"We believe they are going to the launch pad to hibernate under the protection of the crane housing room during the winter and possibly to mate, as well," Reed says.

At the top, males greet females, and females selectively decide which male they want.

In mid-air, couples mate. This takes only about a minute.

Once inseminated, females fly into the crane housing room. There they huddle together, clustered on one of the room's walls, to keep warm and protect themselves from predators. Or they squeeze into the room's cracks and crevices.

They'll stay there all winter, living off stored body fat until spring, when they will return to the ground to build nests out of paper and lay their eggs.

Nearly all of the females the scientists collected from inside the crane housing rooms had been mated. "That's how we know the males are mating with them before they go inside," Landolt says.

The males that mated eventually died, having dutifully served their sole purpose in life. Those that miss the opportunity continue to hang in there on their perches, biting, fighting, and filling the air with pheromone to beckon more swarms of females. That swarming goes on until mid-December.

Waiting For Mating

Landolt and Reed have not yet watched this mating ritual from start to finish, and much of what they know about the wasps is still in the hypothetical. During the next few years, they'll set out to find if their ideas are correct.

They hope to go into the Everglades and search for nesting wasps in tall trees to corroborate the theory that wasps are visually mistaking launch towers for trees. These tests can't be done in suburban areas in Florida; the few trees there are invariably near manmade structures that are

taller, Landolt says. He says that even in forests it's common to find wasps in and near, for example, the taller fire towers, as is the case in a number of Florida forests, including the Ocala National Forest.

One aspect of the ritual is certain: both male and female wasps do produce chemicals that make the insects attractive to one another. Landolt and Reed also know for sure that the male's pheremones are released from glands in his tail and head. They removed two glands from that area and extracted them in solvent. In tests in a wind tunnel, females flew to the extract as if the extract were a male.

With the help of a chemist, they will identify, isolate, and then reproduce the chemicals, creating lures for use in wasp traps.

"We envision that the trap would actually be a simulated hibernation site," Reed says. A large container with a small entry hole for females, baited with the lure to draw them to it, could be put somewhere near the launch pad. The container would keep females warm and allow them to cluster together, so they wouldn't seek another overwintering spot in the launch tower. Reed says the trap would face the south or west sides, which are warmer, because that's where the wasps tend to be. Then, one cold evening when the wasps are quiet and clustered closely together, NASA personnel could climb up to the trap and vacuum up the unsuspecting females or completely remove the trap from the site.

Another alternative, he says, might be to build wood trap towers around the vegetation that surrounds the launch pad. "The launch pad is a huge stimulus, so there's no way we could build something taller," he says, but if trap towers were at least taller than the vegetation, perhaps they would attract the wasps leaving the vegetation, intercepting them before they can get to the launch pad. The wasps would be welcome to stay there, instead of causing problems at the pad.

Reed points out that development of both trap and lure will take several years of research.

BARRY FITZGERALD

Entomologist Peter Landolt prepares some of the 1,000 or so wasps collected for transport back to the lab for study. (K-3455-13)

NASA's Unstung Heroes

This work is being funded by NASA, amid concern for employee and equipment safety, Landolt says.

In the 5 years that the wasps have been making their annual swarm to the launch pad, only one NASA employee has been stung—despite the large numbers of wasps there. Landolt points out that males don't sting at all, and females usually only sting when they are in their nests on the ground—and that's to defend their home and their young.

BARRY FITZGERALD

Hoping to devise a way to keep paper wasps away from the space center's towers, entomologists Peter Landolt (left) and Hal Reed collect specimens for further studies. (K-3454-3)

"But just seeing a thousand or more wasps buzzing around at 300 feet can in and of itself be hazardous," he says. And painters and electricians must regularly go up onto the pad to repair it after each shuttle lift-off. In Reed's words, "Every time we go up on the pad collecting wasps, there's a hoard of people up there working."

Landolt interjects, "When we were collecting wasps this last time, there were so many in the room that they were on us and in our clothes; I had two in my pockets. If you pinch them while they're under your clothes, you'll get stung."

And, he says, the sting of a paper wasp "hurts no less than the sting of, say, a yellowjacket wasp. I can testify to that from experience."

Aside from the potential employee hazard, NASA wanted to ensure that the wasps would not enter the shuttle's electronic and mechanical equipment.

"Obviously a shuttle lift-off is an effective and quick means of controlling the wasp problem," Reed says. But NASA needed a less drastic way to kill the wasps in between lift-offs.

They had been spraying chemical insecticides, but once again concern for the sensitive equipment—plus a desire to keep the chemicals out of

HAL REED

Paper wasps swarm near the top of Bok Tower, a tourist attraction in Lake Wales, Florida.

the center because it's located on a wildlife refuge—spurred the officials to seek nonchemical means.

And so it came to pass that ARS got a call for help from Larry Gast, who is in charge of the space center's grounds care, "which includes handling everything from alligators and armadillos to weeds at the center," Landolt says.

As a former employee of the Insects Affecting Man and Animals Research Laboratory, in Gainesville, Florida, Gast knew that ARS scientists have plenty of pest-control expertise; he'd already consulted with ARS for help in controlling fire ants, mosquitoes, and other unwanted insect visitors.

That lab sent him to the Attractants lab next door, where he was introduced to Landolt and Reed, experts in natural insect attractants.

When they develop a sex lure and trap system, NASA won't be the only beneficiaries. Wasp-plagued officials at Disney World in Orlando, Florida, will also breathe a sigh of relief.

It seems that the wasps have been swarming to the top of Disney World's Gondola ride, which carries passengers from one end of the park to the other.

"The wasps are aggregating at the tops of the ride's support piers," Reed says, "and as people glide by the Gondola, they see the wasps and get upset." Two years ago, operators were forced to shut the ride down for this reason.

Reed has visited the amusement park to assess the extent of their less-than-amusing problem. Wasp numbers vary; they've had as few as 100 or as many as 1,000. He points out that although the problem is seasonal—occurring mainly in fall and early winter—Disney World has already met with him to discuss using the technology when it's ready.

Swarming Tourists

Officials from two tourist towers, Bok Tower in Lake Wales and Citrus Tower in Clermont, have also reported the presence of wasp swarms and have also expressed interest. "We've collected there," Reed says, "and the swarms on the tops of those towers are at least as big, maybe bigger, than those at the shuttle site."

At Citrus Tower, which an orange grower built in the middle of his groves, wasps swarm right to where tourists stand to overlook the groves. The very top of Bok Tower houses employee offices—which the wasps readily enter to disturb employees. That tourist attraction is located in the midst of public gardens.

Landolt and Reed often collect and study the wasps at these towers and at the fire towers mentioned earlier, in part because there are lots of occasions NASA won't permit them on the launch tower.

"Anytime there is any threat of a storm or high winds, NASA doesn't allow us to go up on the pads, for safety reasons," Reed said. Florida storms frequently bring lightning, and the tower "is like a big lightning rod," he says. During high winds, the danger of someone falling off may close down the pad. "They're very safety conscious there," he says.

Yet another obstacle to launch pad entomology: When the shuttle blasts off, "the wasps are completely burned up, which leaves us nothing to study," Landolt says.

Despite still one more stinging obstacle—NASA's budget restrictions—the scientists are gradually building a base of knowledge about these common but poorly understood wasps. From that, they hope to develop an effective lure and trap system. That should be within the next 5 years, Landolt says.

The wasps may yet relinquish their launch pad lover's lane.—By **Jessica Morrison Silva,** ARS.

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Ticked Off About Babesiosis

RANDALL MORGAN

ARS microbiologist Willard Goff (seated) and Washington State University professor Terry McElwain examine a *Babesia* gene sequence. It directs production of a protein that is a candidate for babesiosis vaccine. (K-3522-7)

Even though there hasn't been a major outbreak of bovine babesiosis—better known as tick fever—among cattle in the continental United States since the 1940's, the disease remains a threat to American livestock.

"There is no vaccine that you can legally use with cattle in this country," says ARS research microbiologist Willard L. Goff at Pullman, Washington. "The vaccine used in other countries contains a live but weakened form of the *Babesia* microorganism. In certain cases this vaccine has been known to cause the disease itself."

And drug treatments for infected cattle are not an option here. These substances may persist in animal tissue and could find their way into the meat we eat.

With no vaccine and no drug, American cattle herds are susceptible to this major disease of cattle worldwide. The parasite responsible for the disease is transmitted by *Boophilus* ticks—tiny tropical arthropods that could take up residence in the warmer parts of the country, like Texas or Florida. "If that were to happen," says ARS research entomologist David Stiller, "it could take years to eliminate the ticks. "And during that time, the cattle industry could face losses as high as $500 million a year."

That's why ARS scientists and their colleagues want to produce a new vaccine for cattle and a new and highly accurate test for diagnosing the disease. Goff and Stiller work with researchers in the Department of Veterinary Microbiology and Pathology at Washington State University, Pullman, and the Department of Infectious Diseases at the University of Florida, Gainesville.

A future payoff of the team's research could be increased sales of U.S. livestock in developing countries eager to import American animals to improve native herds. Currently, Holsteins, Herefords, and other breeds raised in the United States are not exported to some tropical or subtropical countries because the U.S. livestock cannot be vaccinated and thus lack resistance.

Advances from these laboratories might help veterinarians better protect and treat other animals—like horses, sheep, goats, pigs, cats, and dogs—that can contract this disease.

New findings from the scientists may also help medical researchers studying malaria; the two diseases share many common features.

And the team's work might aid researchers investigating *Babesia microti,* a species normally found in rodents, but also the culprit in at least 100 human *Babesia* infections. The tick *Ixodes dammini* (northern deer tick) can transmit *B. microti* to humans, and is among the 8-legged mini-villains that can also spread Lyme disease. Because the babesiosis research may someday benefit human health, the U.S. Public Health Service and National Institutes of Health have funded portions of the babesiosis research.

What If ...

If Boophilus ticks were to re-enter the United States, they would most likely originate from Mexico, Puerto Rico, or the Virgin Islands. To prevent an invasion from Mexico, USDA's Animal and Plant Health Inspection Service (APHIS) closely monitors shipment of cattle across the border, carefully checking animals to be sure ticks have not burrowed into their hides.

Ranchers doing business in the buffer zone along the border routinely immerse their herds in a powerful acaricide to kill ticks.

Should U.S. scientists worry about a cattle disease that strikes herds in other countries? You bet!

RANDALL MORGAN

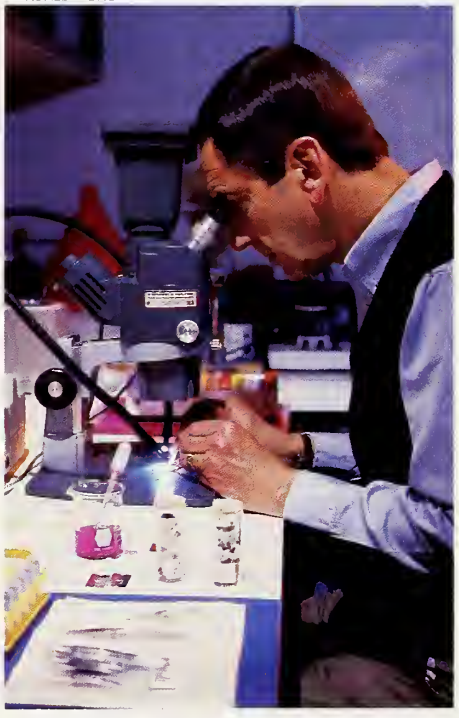
Microbiologist Carl Johnson loads a sample of *Babesia* extract on a gel that will identify proteins associated with *Babesia* parasites. (K-3522-12)

Ticks that transmit bovine babesiosis harbor *Babesia*, a protozoan (single-celled microorganism). Basically, when infected ticks bite cattle to feed on blood, *Babesia* living within the ticks' salivary glands enter cattle bloodstreams and invade red blood cells. Symptoms, which include fever, anemia, loss of appetite, and—in dairy cattle—a drop in milk production, can occur as soon as 8 to 10 days after the animal is bitten. The disease is not always fatal, but adult cattle are more likely to die from it than younger animals.

To thwart the dangerous protozoan, the researchers are carefully studying *Babesia* proteins. These molecules may be the key to producing a vaccine that would trigger an immune response in cattle.

"We would like to be able to inject cattle with a protein-based vaccine," says Terry F. McElwain at Washington State University. "We want a vaccine that stimulates cattle antibodies not only to block the protozoan from entering red blood cells, but also to kill the microorganism."

RANDALL MORGAN



Entomologist David Stiller dissecting a *Babesia*-exposed tick. Researchers have raised the possibility that proteins in the tick's salivary glands may be relevant for use in a vaccine. (K-3521-3)

So far, the team of scientists has identified more than a dozen proteins that are potentially useful in an improved vaccine. They have cloned several genes that cue protein production in the protozoan.

"With the genes, we have the means to test each protein as a potential vaccine," says McElwain. That's because, in the laboratory, these genes can be inserted into useful bacteria, which act like tiny factories, churning out enough protein for the scientists to study. "Normally, the protozoan doesn't make a large enough supply of protein for our tests," he explains.

A new vaccine might take another 5 years to develop, McElwain estimates. After that, it would have to be approved by APHIS.

A potential spin-off of the vaccine research may be an easy-to-use and more accurate test that veterinarians and ranchers could use to detect the four *Babesia* species that infect cattle. Today's techniques for analyzing blood samples from cattle, or tissue from ticks, don't work well enough if infection levels are very low.

The diagnostic kit of the future might be based on new probes, called monoclonal antibodies, that can seek out and bind to a specific *Babesia* protein. The researchers have made and patented several such probes, but more work is needed.

Another option: probes that can scout out the protozoan's genetic material (DNA). Goff and colleagues earlier proved DNA probes successful in detecting another blood parasite, *Anaplasma*, in both cattle blood and tick tissues [See *Agricul-*

tural Research, September 1988].

For *Babesia bovis,* one promising DNA probe is known as Bo6, says Douglas P. Jasmer of Washington State University. He is one of the scientists who isolated and is now testing this DNA detector. "A comprehensive diagnostic test probably has to be made up of four probes—one for each of the cattle *Babesia* species," says Jasmer. "We are working on probes for *Babesia bovis* and *Babesia bigemina,* the two species that are the most widespread and cause most losses worldwide."

Each bovine *Babesia* species is composed of numerous strains (the Mexican and Australian strains of *B. bovis* are an example). Because cattle are often shipped from one part of the world to another, any practical diagnostic kit must be able to detect any of the world's geographic strains of *Babesia.*

"The key," says Goff, "is to find a protein or a piece of the DNA that is common to every strain. Otherwise, you face the enormous, if not impossible, task of producing a separate diagnostic kit for every strain that is out there."—By **Marcia Wood,** ARS.

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APHIS / USDA

Boophilus ticks, seen here feeding on a cow's tail, are responsible for transmitting babesiosis or tick fever.

New Tactics for Ticks

ARS researchers have developed a new wrinkle in attacking ticks that transmit babesiosis. They crossed two species of ticks—*Boophilus annulatus* and *B. microplus*—to produce sterile male hybrids. And last year, with these hybrids, researchers began a tick attack that relies on biocontrol instead of chemical control.

"If the plan works, it could supplement a USDA eradication program at the Texas-Mexico border," says Ron Davey, ARS entomologist at the Cattle Fever Tick Research Laboratory in Mission, Texas.

"Besides Mexico, these ticks are widespread in the Caribbean, including the U.S. Virgin Islands and Puerto Rico," says Davey.

The impetus for reducing tick numbers is just as strong as protection against disease. In 1989, ARS entomologist Glen Garris estimated that ticks alone cost Puerto Rican beef and dairy producers more than $38 million in such costs as lost milk production and reduced weight gains.

Davey and co-workers mass rear hybrid tick larvae—both male and female. When the sterile male hybrids mate with normal female ticks, the eggs are infertile. But a bigger payoff comes from the hybrid females. Although fertile, their male offspring are sterile. "We expect this phenomenon will play havoc with native tick numbers and cause a population crash," says Davey.

ARS entomologist Joe Despins released 40 million hybrid larvae in the U.S. Virgin Islands 5 months before Hurricane Hugo interrupted his work. Researchers plan to restart the program this summer.

A computer model—BCTSIM for Boophilus Cattle Tick Simulation—developed by ARS agricultural engineer Dan Haile and entomologist Gary Mount at the Insects Affecting Man and Animals Laboratory in Gainesville, Florida, provided the attack plan based on estimates of the number of native ticks in the test plots and climatic conditions.

In preliminary simulations, the computer predicted that in the 1,209-acre test area, hybrids will outnumber ticks by more than 50 to 1, a ratio that should prove overwhelming to the native tick population.

Initially, livestock will be treated with insecticides to guard against tick-borne disease. But once the native tick population drops down to a manageable level, no chemicals should be needed.—By **Linda Cooke,** ARS.

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Squeezing Oil From the Primrose

The reddish-brown seeds of the evening primrose flower are barely the size of sesame seeds. Yet the fatty oil they contain has fueled a torrent of controversy about its therapeutic value.

Touted as a remedy for a host of ailments—including allergies, rheumatoid arthritis, cancerous tumors, high blood pressure, premenstrual pain, even hangovers—the oil is without question a major source of gamma-linolenic acid.

This polyunsaturated fatty acid is a precursor of prostaglandin E1, a hormone-like substance produced by the body. Prostaglandins have been linked to such metabolic functions as muscle contraction, heart rate, sensations of pain, and the regulation of hormones.

Proponents point to tests that demonstrate the oil's prostaglandin-enhancing benefits which, they claim, abate symptoms of several illnesses.

Critics say medical claims cannot be accepted until there is proof that prostaglandins improved a particular malady and that a lack of gamma-linolenic acid is the sole factor limiting prostaglandin production.

"I would say the claim that the oil is a useful treatment for atopic eczema, an allergic skin condition, has already been proven," says James Duke, an ARS botanist and renowned expert on herbs and medicinal plants. "But the jury's still out on the other claims. The oil may be helpful. We just don't know yet."

Despite the clinical debate, evening primrose oil is considered to be of commercial value. Growers from at least 15 countries each year produce thousands of tons of seeds, although the United States and Canada account for only about 300 tons annually. The oil contains just 10 percent gamma-linolenic acid but sells for up to 80 cents a gram in some places, or about $22 an ounce.

"There are not many potential sources of the oil, which is probably one reason it is so expensive," says Fabio Favati, a visiting scientist from Pisa, Italy, working with chemist Jerry W. King at ARS' Northern Regional Research Center in Peoria, Illinois. He has been researching the use of supercritical fluids for the extraction of natural products, including evening primrose oil.

The oil is normally obtained through conventional extraction processes that rely on hexane or other toxic chemicals to separate it from the meal. But King and Favati have found that supercritical fluid extraction is safer, more efficient, and faster than any other extraction process in use.

Supercritical fluids are highly compressed gases, such as carbon dioxide, with physical properties between those of a liquid and a gas. In an extraction chamber, the fluid flows through a test sample—in this case ground-up primrose seeds—and removes the oil from the meal. The gas is then vented and recycled for later use.

"With solvent extraction, there is always some chemical residue left once you have finished," Favati says. "But with supercritical carbon dioxide, you never have that prob-

Evening primrose, a source of gamma-linolenic acid.

PERRY RECH

Evening primrose seeds (background), seed meal before the oil is extracted (center), and (foreground) meal and oil in test tube after extraction by supercritical carbon dioxide (K- 3538-1)

lem. The extracted meal is pure, and the amount of recovery is very high."

At 122°F and 10,000 pounds of pressure per square inch (psi), Favati was able to extract more than 95 percent of the oil in 10 minutes. Dropping to 7,250 psi with the same temperature, recovery was more than 87 percent in 14 minutes.

Solvent extraction requires more time for less product recovery, he says. In addition, conventional extraction includes the cost of solvent waste disposal and exposure of operating personnel to hazardous chemicals, neither of which figure into supercritical fluid extraction.

Supported by grants from the National Research Council of Italy and USDA's Office of International Cooperation and Development, Favati will soon turn his efforts to enrichment studies to improve the quality of the gamma-linolenic acid extracted from evening primrose oil.—By **Matt Bosisio,** ARS.

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Turnips...

A New Hit With Sheep

A familiar table variety of turnip may be on the verge of acquiring numerous new four-footed fans.

The turnip, called Purpletop, has turned out to be a hit with grazing sheep, reports Steven P. Hart, an animal nutritionist. Hart works at the Forage and Livestock Research Laboratory operated by USDA's Agricultural Research Service at El Reno, Oklahoma.

"Livestock producers should like the fact that turnips produce twice the dry matter of winter wheat for forage," says Hart. "You can get about 4 tons of dry matter per acre for grazing from turnips."

Hart began feeding studies with sheep and turnips in 1986. Additional feeding trials are planned.

"The sheep gain well on turnips," he notes. "They'll eat the leaves first, then the top of the turnip. Then they'll actually eat down into the heart of the turnip, but they don't pull them up out of the ground."

In the feeding trials at El Reno, sheep on Purpletop gained an average of 0.45 pound per head per day, compared with average daily gains of 0.44 pound per head for sheep grazing winter wheat.

Turnips have about 80 percent total digestible nutrients (TDN) and 16 to 20 percent crude protein, compared with 80 percent TDN and 10 percent crude protein in corn grain, according to Hart.

"The nice thing about turnips is that they'll survive light freezes and still give something for the animal to eat," he says.

Another point that should please livestock producers is the stocking rate possible on turnips.

"In our feeding trials, we only put about five head of sheep on each acre of wheat," Hart recalls. "But we've put as many as 20 head of sheep per acre on turnips. You can easily graze at least twice as many sheep on turnips as on wheat."

Hart plants the turnips in late September. They're ready to be grazed about a month later and generally last until Christmas.

"After that, you'd be free to use the land for something else," he says. "One real advantage of turnips over wheat for grazing is that with turnips, you don't risk problems on your federal program acreage allotment like you might with wheat."—By **Sandy Miller Hays**, ARS.

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Natural Gum Finds Many Uses

What was once an undesirable by-product of sugar processing might turn out to be worth big bucks.

This byproduct, called levan, is a natural gum made by microorganisms found in soil and in certain plants, such as sugar beets. It serves either as the micro-organism's food reservoir or a natural defense.

Levan may be used in printing, cosmetics, sweeteners, as a thickener, and possibly a human blood plasma extender. Agricultural Research Service scientists have found and are patenting a way to rapidly produce the substance by using the soil microorganism, *Bacillus polymyxa*.

Youn W. Han, a microbiologist at ARS' Food and Feed Processing Research laboratory in New Orleans, Louisiana, says that growing a certain strain of *B. polymyxa* on a sucrose solution increases levan yields. Han says the isolated strain of *B. polymyxa* produces three times as much levan and in a purer form than other levan-producing microorganisms tested on the sucrose solution.

At least 28 soil microorganisms make levan, he says.

Two years ago, Han and co-inventor Margaret A. Clarke of Sugar Processing Research, Inc., of New Orleans, began working on ways to diversify the sugar industry. Competition from corn syrup, which is used as a low-cost sweetener, had cut into the sugar industry's market.

"The sugar industry needs to find other valuable products besides sugar," Han reports.

This value-added product is similar to two other natural gums developed by ARS—dextran and xanthan—which are now used for a variety of industrial purposes, Han says.

Dextran is made by *Leuconostoc mesenteroides* and xanthan gum is produced by *Xanthomonas campestris*. Dextran and xanthan gums are polysaccharides, which are natural gums that can be ingredients in ink, gelatins, and perfumes. Levan is also a polysaccharide and could replace certain gums now used as ingredients, Han says.

San Diego-based Kelco Co., a division of Merck Co., of New Jersey, has signed a research and development agreement with ARS to commercialize the levan-production technique developed by Han and Clarke. Once a patent is granted, Kelco holds first rights to license the technology.

"There are a lot of potential uses of levan," Han says. "If properly developed it may be useful in food and other industrial applications."—By **Bruce Kinzel**, ARS.

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Sweet Dreams for Plants

Storage centers all over the world maintain stocks of seeds to help preserve the natural diversity of plants. But what do you do with plants that are not commonly grown from seed—plants such as sweetpotatoes?

You could plant all the varieties of such a crop each spring, harvest and overwinter them, and repeat the cycle year after year. But that continually risks losing a variety to disease, predators, or plain bad luck.

Tissue culture storage can eliminate those problems, but plants such as sweetpotatoes quickly outgrow the test tubes in which they are stored or use up the growth media. And with conventional tissue culture techniques, plants have to be recultured every 90 days, a very time-consuming process.

PERRY RECH

Technician Kitty VanSickles checks sweetpotato plants that are nearly in suspended growth. (K-3461-14)

But ARS horticulturist Robert L. Jarret has developed a way to slow sweetpotatoes down to almost a complete stop—to put them into deep sleep without affecting them in the long term. This would make tissue culture storage much more practical.

"It's like suspended animation," Jarret says.

He uses a combination of lowering the temperature to 70°F and reducing the carbohydrate level in the growth media from 3 percent to 2 percent.

"These conditions allow perfectly normal growth except it is very, very slow. The leaves still look bright and green," he says.

So far, Jarret has been able to stretch the time between tissue culture regenerations to 12 months.

And when he takes the plants out of the test tubes and transfers them to soil, the plants immediately begin growing at a normal rate again.

"That was really the hard part—not slowing them down but making it so the treatment would not cause any changes in plants when we needed them to grow normally again later," says Jarret. It was also difficult to find a combination of conditions that would uniformly affect all the different varieties. At the moment he has more than 600 varieties of sweetpotatoes in slow growth storage.

Jarret hopes to stretch the time between regenerations up to 2 years.

To achieve this, he is studying the effect of changing photoperiod (the light/dark cycle) along with nutrition and temperature. "There could be synergistic effects from altering all three factors that would cause the plants to slow down even more," he maintains.

Jarret is also looking into the possibility of controlling growth using hormones such as abscisic acid (ABA). "Under the right conditions, the addition of ABA may be able to just stop a plant in its tracks without harming it."—By **J. Kim Kaplan,** ARS.

Robert Jarret is at the USDA-ARS Plant Introduction Research Station, Flynt Building., Griffin, GA 30223-7255 (404) 228-7207. ◆

Predicting Nematode Damage to Soybeans

If a soybean plant gets plenty of water and nutrients and has no diseases, its growth can be predicted by currently available computer models. Other models are available that can predict the growth and development of pests on crop plants.

But what about what pests do to plants and what plants do to pests as conditions change daily? There are many dynamic interactions between the two that determine how a crop will fare. Predicting how a crop will grow requires understanding those interactions.

Plant pathologist Sally Schneider is part of a five-person team developing such a computer model. Schneider, based at the ARS Crops Research Laboratory, Oxford, North Carolina, is developing a new soybean cropping system model in cooperation with an entomologist, a plant modeler, a nematologist, and a biomathematician from North Carolina State University.

"This model should be adaptable to a range of plants and soil-borne pests—insects, fungi, or nematodes (microscopic worms) since it calculates the status of both the plants and pests throughout the growing season," Schneider says.

The new model is aimed at predicting how soybean cyst nematodes will affect soybeans and vice versa. It combines a model for soybean growth, SOYGRO, with SIMCYST, a submodel for the nematodes. Other members of the research team are working on weed and insect submodels.

The nematode submodel uses a combination of biology and mathematics to estimate the number of nematodes by periodically calculating worm numbers in each life stage.

So far the nematode model has successfully predicted nematode populations observed in greenhouse and growth chamber studies. SOYGRO has already been tested with field data. The combination model is expected to be ready for field testing in a year.

The result: Scientists and farmers may be able to make more realistic predictions of crop yields and better decisions on how to manage crops.—By **Dvora Aksler Konstant**, ARS.

Sally M. Schneider is at the USDA-ARS Crops Research Laboratory, P.O. Box 1555, Oxford, NC 27565 (919) 693-5151. ◆

Shedding Light on Genetics and Environment

Soaking up rays of blue light—that's life in the fast lane for a small plant in the mustard family known as mouse-ear cress.

If grown under blue light, the little cress whose Latin name is *Arabidopsis* ,produces sparse foliage, blooms early, sets seed, and quickly dries up and dies. But under red light, life proceeds more slowly for *Arabidopsis;* it produces many more leaves, blooms later, and yields more seed.

Chemist Kenneth Eskins at ARS' Northern Regional Research Center, Peoria, Illinois, studies the effects that different light signals have on photosynthesis and on the regulation of plant growth, flowering, and seed formation.

So far, his growth chamber studies on the *Arabidopsis* plant model, as well as crops such as spinach, corn, and soybeans, have shown that light quality (wavelength) and irradiance level (intensity) can regulate expression of certain genes.

The research points out a basic principle: Even if all plants were created equal, they wouldn't necessarily express their genetic potential in the same ways. During their life cycles plants have biochemical reactions to light, heat, drought, and additional environmental cues that influence the abundance of seed and other tissues they yield, says Eskins.

Further research on such genetic/environmental interactions may help genetic engineers and plant breeders design crop plants specifically tailored to their environments.

Some more immediate practical spinoffs may ensue. For example, it might be possible to increase the amount of fresh vegetables that could be grown in hydroponic systems by providing special wavelengths of light during certain plant growth stages.

Increasing efficiency in hydroponics could lower the cost of producing vegetables near urban centers.

The idea of artificially lighting major field crops is obviously less practical, but reflected light from mulches might be put to good use on high-value crops. Experiments led by ARS soil scientist Patrick G. Hunt at Florence, South Carolina, show that tomatoes mulched with red plastic—which reflects all but red light—produced 20 percent greater yields than tomatoes mulched with black plastic. *[Agricultural Research,* March 1988, p. 4]—By **Ben Hardin,** ARS.

Kenneth Eskins is in USDA-ARS Plant Biochemistry Research, Northern Regional Research Center, 1815 North University St., Peoria, IL 61604 (309) 685-4011. ◆

Letters

Tuber or Not Tuber

[With reference to "Breeding Super Sweetpotatoes," November 1989]

In many respects the article was excellent, but sweetpotatoes are *not tubers* but rather are *tuberous roots,* true roots that simply "go to fat" as they stored their polysaccharides. Since the potato *(Solanum tuberosum)* is a true tuber (a stem structure), it is easy to confuse the terminology. But potatoes and sweetpotatoes are so dramatically different in terms of their taxonomy and structure that it is important to not refer to the edible portions of the sweetpotato as tubers but rather as tuberous roots.

I offer this small criticism in hopes of continued improvement of an already high quality publication. (At least you did not call them yams!)

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